FARMERS' BULLETIN 1177
UNITED STATES DEPARTMENT OF AGRICULTURE

CARE AND IMPROVEMENT OF THE FARM WOODS

IMPROVEMENT cuttings help the woods in the same way that weeding helps field crops.

Trees grown close enough together in the farm woods so that their tops are in contact produce high-grade saw logs.

Young trees should be coming up in the openings. They should be encouraged by keeping out stock and fire, and by proper cutting methods. Sometimes it is necessary to plant.

In cutting timber take out inferior species to a smaller diameter than the more valuable species and remove *all* defective trees in order to improve the *quality* of the farm woods.

Grass in the woods is a sign that the trees are not close enough together or that the woods are being mistreated. Pasturing and timber raising on the same area are mutually disadvantageous.

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Contribution from the Forest Service.
William B. Greeley, Forester.
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Have Related,

THE CARE AND IMPROVEMENT OF THE FARM WOODS.

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CONTENTS.

INTRODUCTION.

THE FARM WOODS furnishes an essential portion of the farm output. Attention given to providing good conditions for the growth of the trees which it contains will pay the farmer well both in comfort and in cash. If properly cared for, the woods will furnish at all times a convenient supply of timber, fuel, fencing, and the like for home use and at intervals will yield valuable material for market. If neglected or abused, it is bound to deteriorate, and may eventually disappear altogether. On farms which have no woods the owner will often find neglected corners or poor-soil slopes where planted trees would be a profitable investment. The most should be made of these, for there are times when wood is as urgently needed as the products of the kitchen garden. The aim of this bulletin is to point out methods of caring for the farm woods and improving it so as to make it contribute as much as possible to both the owner's convenience and his purse.

By far the greater number of farm woods are in need of improvement. Poorer species are in the majority and are crowding out the better ones, many of the trees are overmature, some show evidence of attack by insects or disease, some are dead, young trees are entirely wanting in the open places, and grazing is allowed to the extent of damaging the older trees and preventing reproduction. Improvement of these conditions can be secured through the judicious use of the axe, by assisting natural reproduction, by the exclusion of

stock from at least portions of the woods, and where necessary, through planting or sowing.

TYPES OF WOODS.

There are two general types of farm woods, each of which requires a different method of handling: (1) Those which are characterized by the presence of old trees which dominate the stand, and (2) those which are made up of a nearly even-aged stand of second growth.

(1) Where there are old trees which dominate the stands to a certain extent these old trees may almost totally exclude the younger growth, or they may exist only as a few scattered individuals throughout the stand. Such material is very likely to be deteriorating in quality, and the problem is to remove it, and at the same time provide for a new stand of seedlings. From the standpoint of strict business management timber when mature should be cut just the same as wheat or oats; and usually this is also desirable for the good of the woods itself. No dead or diseased timber should under any circumstances be allowed to stand. The first operation necessary, then, in woods of this type is to cut out at once the dead and diseased material. The second is to cut the mature living trees as soon as sufficient reproduction is started in the openings and marketing conditions permit a satisfactory sale. Heavy stands composed almost wholly of mature trees should not be removed all at once unless the owner expects to provide for the new crop by planting.

In woods where the stand of old trees is not dense and reproduction is already well started, the mature trees should be cut as soon as practicable. Unless removed these will suppress and kill out young trees which would eventually be highly valuable.

(2) Where the woods is made up of a nearly even-aged stand of second growth, trees of undesirable species may predominate and may be crowding out the better ones; or the stand may be overcrowded; or it may be understocked and not reproducing. The improvement of such woods may be brought about by various cuttings, known as "improvement cuttings," and by practices discussed under the heading, "Methods of regeneration."

ESSENTIALS OF A GOOD FARM WOODS.

The woods crop, like any other, should be judged by its quantity and quality. To secure a full stand of trees of high quality, therefore, should be the end sought. Fortunately, the quality of timber is very largely determined by how close together the trees are. To be of high quality, timber must be, to a considerable proportion of its height, free of limbs, which are the cause of knots; it must be tall; and it must not decrease rapidly in diameter from the

butt to the top of the last log. In a dense stand of timber there is considerable competition for sunlight among the individual trees, with the result that height growth is increased. Trees in crowded stands are usually taller than those in uncrowded stands of the same age. When the tres are crowded so that sunlight does not reach the lower branches, these soon die and become brittle; they then fall off or are broken off by the wind, snow, or other agencies. By this process trunks are formed which are free of limbs, and hence of high quality. Further, when trees are crowded their diameters do not decrease rapidly from the butts to the tops. In uncrowded stands just the opposite is true: height growth is usually less; the lower branches continue to live, increase in size, and form large knots; and there is a much greater taper in the trunks of the trees. It is evident, therefore, that trees in the farm woods should be so crowded that the crown or top of each individual tree may be in contact with those of its nearest neighbors. A crowded stand of trees produces not only a larger number but also a greater proportion of high quality saw logs than an uncrowded stand of an equal area. This is of vital importance, because the price of logs of first quality is usually from one and one-half to two times as much as that paid for logs of poor quality.

STOCKING.

The approximate number of trees which should be present per acre is given in Table 1. The figures are applicable to oak, aspen, hickory, elm, and ash, but are from 15 to 20 per cent too low for maple, basswood, yellow birch, beech, and white or red pine. For shortleaf, loblolly, and slash pines the table shows from one-third to one-half the number of trees in well-stocked stands.

TABLE 1.—*Number of trees which should be present per acre.*[1]

Diameter.[2]	When diameter of trees ranges from—				When trees are all of a uniform diameter.
	2 to 10 inches.	2 to 14 inches.	6 to 18 inches.	10 to 24 inches.	
Inches.	*Trees.*[3]	*Trees.*[3]	*Trees.*[3]	*Trees.*[3]	*Trees.*[3]
2	400	300	.....	.....	2,000
4	180	130	.....	.....	900
6	105	75	75	.....	510
8	65	45	45	.....	320
10	50	30	30	30	235
12	.....	25	25	20	170
14	.....	20	20	16	130
16	.....	.....	15	12	100
18	.....	.....	12	11	85
20	.....	.....	.....	9	75
22	.....	.....	.....	8	65
24	.....	.....	.....	7	55
Total per acre	800	625	222	113	.....

[1] Data furnished by Prof. E. L. Sponsler, University of Michigan.
[2] Diameters taken at 4½ feet from the ground.
[3] Of the respective diameters indicated in the first column.

SPECIES.

From the marketing standpoint, some species are preferable to others. Black walnut, white oak, and yellow poplar, for instance, are now of more value than basswood, red gum, or beech. It is probably best, however, to grow those species which will produce the largest amount of material within a specified time rather than to attempt to grow the species most valuable now. This means that trees of the most rapid growth which are well adapted to the region and situation and not subject to serious insect or disease [1] attacks should be favored.

The comparative rates of diameter growth of the most important species for which data are available are about as shown in Table 2. For the rates of growth of individual species in different regions Table 4 (p. 24) should be consulted.

TABLE 2.—*Comparative rates of diameter growth of trees.*[1]

Average number of years to grow 1 inch in diameter.	Species.
2 to 4 years	*Cottonwood, black willow, *white willow, *honey locust, *black locust.
3 to 5 years	Shortleaf pine, bald cypress, slash pine.
3 to 6 years	Red gum, *silver maple, *white elm, yellow poplar, chestnut, *hardy catalpa.
4 to 7 years	*White ash, *green ash, *boxelder, *black walnut, white pine, red pine, *butternut, red oak, southern red oak, black oak, *bur oak, aspen, *osage orange, basswood.
5 to 10 years	Hickory, white oak, chestnut oak, paper birch, yellow birch, *hard maple, beech.
8 to 10 years	Red spruce (second growth).
9 to 18 years	Hemlock balsam fir.
18 to 25 years	Northern white cedar.

[1] Table is based on growth of trees in plantations (marked with an asterisk) and in natural forest stands (those not so marked).

The slower-growing species, particularly those in the last four lines, will not reach merchantable size as soon as the others, and from an investment standpoint should not be favored in the young growth, provided some of the more rapid-growing kinds will succeed. The value of these slow-growing species for farm purposes, however, will often make it equally desirable to encourage the growth of at least a few of them if the owner wishes material particularly fitted for his own farm uses.

IMPROVEMENT CUTTINGS.

Any cutting designed to remove some of the trees in a stand for the benefit of the remainder is called an "improvement cutting." When made in stands of seedlings or small saplings, such cuttings are

[1] Chestnut is of rapid growth but is subject to such serious disease attack (chestnut blight) that it should be supplanted by other species.

for convenience designated as "cleanings"; when made in somewhat older stands they are known as "thinnings"; when made in stands where scattered old trees are suppressing valuable young growth, they are known as "liberation cuttings."

CLEANINGS.

Often in young stands some of the less valuable species, such as ironwood, threaten to overtop, crowd out, or damage the more valuable species, such as white ash or yellow poplar; sprouts sometimes arise too thickly from the stumps of trees recently cut; or the reproduction of good species is too dense. In any of these cases some of the trees should be removed. Cleanings are nothing more than the weeding out of the poorer species or the poorer individuals where these interfere with the better ones. The practice of lopping the tops of the inferior species rather than cutting them off near the ground level can be followed. These trees will then continue to live, force the growth of the better species, and still continue to shade the ground. Both to decrease costs and to avoid overcutting, only those inferior trees which are actually interfering with the better ones should be removed. The material cut out is usually too small to pay for the expense involved. The justification for cutting it lies in the bettering of the remaining stand.

THINNINGS.

In from 15 to 20 years young stands ordinarily reach a condition which makes the cutting out of some of the trees advisable. By thinning, the stand of trees that is to form the final crop can be regulated and improved. The principle is the same as that applied by truck gardeners or orchardists who thin out their crops to secure the best development of a portion rather than a poor development of the whole. By crowding at the beginning, trees of high commercial quality are produced; but if crowding is allowed to continue after the lower branches die, it will cause stagnation both in diameter and height growth.

The presence of dead or dying trees in the stand, a very dense interlocked crown cover, stems very slender in proportion to their height, or an apparent stagnation in the height growth, indicates that a thinning is needed. Unless the condition of the stand makes earlier thinnings desirable, the best practice is to defer the first one until the product is merchantable and of sufficient size to pay for the operation. Thinnings should be repeated as often thereafter as the material has accumulated in sufficient quantity to pay for the cost. Cordwood and post material will ordinarily be obtained from the first thinnings and larger sized material from the later ones. In

a small woods, thinnings may be carried on by the owner at odd times at no cost other than his own labor. When poles are cut for some farm use, a little care in selecting the trees to be cut will insure a crude form of thinning.

As a rule, trees of the least prospective value should be removed. In any young stand, the trees may be assigned to several classes according to the position of their tops or crowns—dominant, codominant, intermediate, suppressed, and dead. Dominant trees are the tallest ones, whose tops receive almost complete sunlight; codominant trees are those of slightly less height with relatively narrow tops which are not fully exposed to sunlight; intermediate trees are considerably smaller than those of the first two classes, but still healthy because their tops continue to occupy open spaces in the canopy; suppressed trees are those hoplessly behind in height growth and which will either be killed by the shade of the other trees or continue to exist only as stunted individuals. The trees which remain after a thinning should, as a rule, be those which are of the best form regardless of species, the most rapid growing, and presumably of the highest final market value. The trees to be removed should, accordingly, be the dead ones and those of the least valuable and the most slow-growing species in the suppressed and the intermediate classes; but insect and disease infected specimens of all classes should by all means be taken out. To obtain a proper opening of the crown canopy, some of the dominant and codominant trees may also have to be cut. In thinning, it must be remembered that the condition of the soil very much influences the health and vigor of the forest trees. The soil should be kept fresh, soft, loose, and free of a mat of grasses. With field crops. this condition is attained by cultivation. In woods it must be secured by keeping the ground shaded. In making thinnings, therefore, it is desirable to retain any of the intermediate or suppressed trees which are necessary for shading the ground.

The extent to which the crown canopy of a stand may be opened depends largely upon the rate of growth of the trees and their demands for light. In general, openings should not be so large that they will not close again within from three to five years through the growth of the remaining tree tops. In stands of rapid-growing trees, such as cottonwood, yellow poplar, or red gum, the crown canopy of the dominant class of trees can be opened to a greater extent than in stands of slower-growing species, such as white oak, ash, basswood, etc. Definite rules in regard to the amount of material to be removed are not possible for all conditions, but probably not more than from one-fifth to one-fourth of the trees should be removed at a time.

The returns from thinnings will depend largely upon the market for the material removed. If the material is small and suitable only

for a poor class of cordwood, it is quite likely that the product will not pay for the cost of the operation. It must be remembered, however, that the increased growth and value of the remaining product will fully offset this cost. The material taken out in thinnings can accordingly be considered as net gain. Where the market is good, as in parts of the New England States, thinnings have been made at a net profit of from 10 cents to $2 per cord,[2] and in one 8-acre woods of white pine in Connecticut thinnings netted the owner $44.32 per acre.[3] When the thinning removes material suitable for posts, handle material, hub stock, small piling, or ties, the operation undobutedly will pay for itself.

LIBERATION CUTTINGS.

Scattered old trees suppressing valuable young growth will often be found in those woods which have been formed from seeding

FIG. 1.—Well-stocked stand of shortleaf pine thinned from time to time and the product profitably utilized for lumber, ties, and fuel wood.

by adjoining trees of such an area as a worn-out pasture. The first trees to start often have an abundance of room and consequently form very branchy stems and wide spreading crowns. Such trees will never be of much value for lumber and their wide spreading habit often results in the suppression and killing of younger and

[2] Bulletin No. 2, State Forester's Office, Mass. 1905.
[3] "Economic Thinnings of White Pine," Forestry Quarterly, Vol. V, 1907.

better formed seedlings or saplings which ultimately would be of considerable value if the conditions were more favorable. (See fig. 1.) It is best in such cases to remove the old trees at once. A very similar condition is also found in woods which are the remnants of virgin stands. Scattered old virgin trees remain which, through shading, are hindering the growth of younger trees. Often these older trees, because they at one time grew in a dense stand, have a high commercial value. They should be removed as soon as a satisfactory sale can be arranged.

CUTTING OUT OF VINES.

Such vines as grape, ivy, and woodbine sometimes occur in woods and almost invariably twine about the trunks and throughout the tops of the trees. They affect both conifers and hardwoods and often do more damage than may be commonly realized. When of large size, their heavy foliage and small branches shade out and kill the leaves of the trees. Also by their sheer weight alone they often bend over the tops of the trees, which are thus either killed or rendered very unthrifty. (See fig. 2.) The vines themselves have no special value, and they should accordingly be eliminated by severing the parent stem near the ground. It will be best to carry on this operation while the vines are small and before they have done any appreciable damage; and, if lack of time prevents a thorough job, at least the larger ones which it is readily apparent are doing harm should be cut out.

PASTURING OF FARM WOODS.

Pasturing of woods has been one of the chief causes of their deterioration. The severity of the damage depends largely upon the number of stock and the size of the woods. One characteristic of a heavily pastured woods is the almost complete absence of young growth, or its existence only in small ragged patches as broken or scrubby stuff. Cattle, horses, sheep, or goats eat young seedlings, particularly the hardwoods, trample them out, or brush against them and break them off. Hogs eat the seed and thus prevent reproduction from starting, or root young seedlings out of the ground, and sometimes eat the roots. (See figs. 3 and 4.) In those parts of the southern longleaf pine region where hogs run at will, they are known to do a great deal of damage to longleaf pine seedlings and often damage trees several feet in height. When driven out of the swamps by high water in the late winter and early spring, they root up the longleaf pine seedlings and greedily devour the heavy roots. Observations carried on at Urania, La., have shown stands of several thousand longleaf pine seedlings per acre on areas protected against hogs and no seedlings on adjacent areas which were unprotected.

The old growth is damaged through trampling and wounding of the roots and through compacting the soil to such an extent that it is almost impervious to water. Horses sometimes peel the bark from the trees. Old trees show the abuse in the dying of their tops, in a decrease in the amount of foliage, and often in the beginning of decay at the butts. A light cover of grass then makes its appearance and increases the drying out of the soil.

When the crown canopy of a woods is unbroken, and young growth is not desired, a few head of cattle are permissible. They

FIG. 2.—Large spreading tree of poor timber form in center is interfering with thrifty young trees surrounding it and should be cut out.

FIG. 3.—Illustrating damage done by grapevines in bending over and finally killing thrifty young trees. Vines should be cut out.

should not, however, be turned in when the ground is very soft—when the frost is going out, for instance, or during a rainy season. The soil is too easily compacted at that time. When it is desired to secure natural reproduction hogs may be turned into the woods shortly before the seed is to fall. They will root up the ground and thus put it in good condition for the reception of the seed. Thereafter, however, they should be kept out.

Goats and sheep should be allowed in the woods only when it is desired to clear up brush of undesirable species, so as to make pos-

sible the reproduction of better ones. If the better species are already present in mixture with the poorer ones, some method of cutting, rather than grazing, should be followed to clear the area of the poorer species. Horses should at no time be permitted in the woods.

Stockmen are quite generally agreed that grass produced under the shade of timber is considerably less nutritious than the same species growing in full sunlight. It is also usually much more sparse. The actual value, then, of woodland pasture is small. Two dollars per acre per year is probably a liberal estimate of the value of the forage. Thrifty fully stocked stands of timber will grow at the rate of 250 or more board feet of lumber per year. Adopting only 250 board feet as the growth and assuming the value of the standing timber to be from $10 to $15 per 1,000 feet board measure, the value of the timber growth is from $2.50 to $3.75 per acre per year. Stumpage values are sometimes much higher than this, especially if there is considerable white oak, yellow poplar, walnut, or other valuable species in the stand. If the timber is given good care, moreover, the growth should be as much as 500 board feet per acre per year. The larger value of the woods for growing timber, as compared with the value of its forage only, is apparent.

It must not be thought possible to secure this growth of timber and utilize the woods for pasture at the same time. Grass in the woods is almost an infallible indication that the woods is not fully stocked or is being mistreated. Grass will not thrive without strong sunlight, and in a woods in good condition sunlight reaches the forest

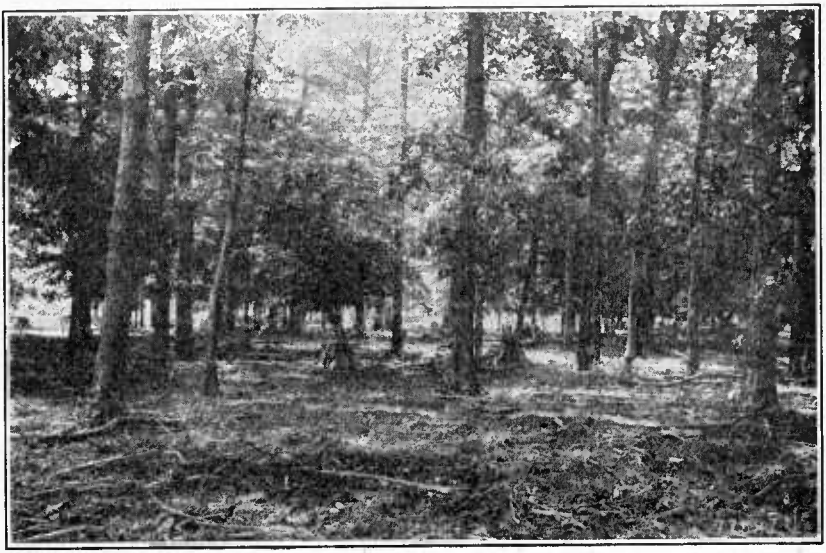

FIG. 4.—Woods in which cattle and hogs have run. No reproduction; roots exposed; results in little growth and a decrease in value of material.

FIG. 5.—A well-managed second-growth woods in Indiana, not grazed. Maximum production of wood.

floor only to a very limited extent. Pasturing and timber production can not, therefore, be practiced on the same area except to the mutual disadvantage of each; and the combination of the two will not pay the owner as well as the practice of either one separately. It must be admitted, however, that the value of the shade to stock may more than offset the loss in timber growth due to the practice of pasturing. Just what this value is, foresters can not say; but to the farmer who pastures his woods and to those interested in timber production as a farm crop, studies looking to the solution of this question would be very helpful in formulating plans for the future. If shade, however, rather than forage is the chief value of the woods to stock, it can doubtless be provided by allowing the stock to range in only a portion of the woodland. The remainder can more profitably be devoted to the production of wood alone.

FIRE PROTECTION.

In the North, because farm woods exist for the most part as small, scattered bodies of timber, which are constantly under the owner's supervision, there need be very little damage from fires. In the South, where farm woods are often of considerable extent, and where it is the very common practice of some people to set the woods afire because of the belief that it improves the grazing, special precautions will need to be taken to keep out fires. It may be possible to plow several furrows around the woods, which will assist in stopping a fire; but perhaps a close watch during the fire season and

vigorous measures to fight fire once started are the best that can be done at present. In addition, an endeavor can be made to arouse public sentiment against setting the woods on fire. Owners are doubtless in some instances indifferent about fires in their woods, because they do not realize that these may do great damage without giving striking evidence of the fact. They burn the fallen leaves and accumulated litter of several years, thus destroying the material with which trees enrich their own soil. The soil becomes exposed, evaporation is greater, and more of the rain and melted snow runs off the surface. The roots may also be exposed and burned. Conditions are such that the vitality of the trees is weakened and their rate of growth decreased. Fires commonly kill a great many of the young seedlings up to 1 inch in diameter. This young stuff is commonly called "brush," but it must be remembered that every large tree was in the "brush" stage once and that the "brush" of to-day will be the large timber trees of the future. Very severe fires kill some of the larger trees and burn through the bark of others. These wounds lower the value of the butt log for lumber, and they afford a ready point of entrance for rot-producing diseases, which often cause deterioration in the quality of the logs for a considerable distance above the wounds. By the entrance of rot the sale value of a tree may easily be decreased by from one-half to two-thirds. Rotten logs are seldom classed as No. 1, and usually as culls. Fires, then, may be expected to destroy the vegetable manure of the forest floor, to kill young growth, to weaken vitality and growth of older trees, and to lower the sale value of timber. Through the killing by fire of the young growth, which permits more light to reach the forest floor, the growth of grass is encouraged and pasturing is probably made somewhat better, but it is believed that, everything considered, the burning of woods to better the pasture does not pay.

INSECTS AND DISEASES.

Damage from either insects or disease is always possible. It is more likely to be serious with some species than with others; and disease is likely to be worse in woods which have been damaged by fire, grazing, lumbering, wind, or any other agency which has served to break the bark or roots and expose the living inner tissues. The damage done by a leaf-eating insect is apparent in the destruction of the foliage. When the insect is one that works under the bark and either bores into or girdles the tree, its presence is manifested by fine sawdust-like particles of wood which fall out of the burrows and collect either around the base of the tree or at the entrance of the burrows. Sap or gum also often exudes from these entrances. When the attack is serious, the leaves of hardwoods change to their

autumnal color, while those of conifers become brown or red. The bark of trees killed by girdling insects becomes loose; and on its inner surface, as well as on the surface of the wood of the tree, there will be found more or less numerous regular wavy passages, or so-called galleries. These are formed by the grubs as they eat their way under the bark. The wood is their food during the course of their development.

The presence of wood-rotting disease is indicated by hollow stems, discoloration, and rot of the wood, and by fruiting bodies. These are the mushroom or bracket-shaped bodies which appear somewhere on the trunk, branches, or roots of the tree, most often at some point where the tree has been wounded. Other types of disease which may seriously damage trees but do not rot the wood may have rather inconspicuous fruiting bodies, but are manifested by an unhealthy appearance of the tree, dying of the branches, distorted twigs or branches, sunken places in the bark, and possibly other indications.

Full information in regard to the damage from either of these sources and the methods of control can usually be secured either from State experiment stations or the United States Department of Agriculture, Washington, D. C.

CARE IN LOGGING.

When the timber in the woods is being cut steps can be taken to insure the perpetuation of the woods and at the same time improve the quality of the stand. Lumbering operations which remove only trees of high quality, such as white oak or black walnut, and leave dead, dying, insect attacked or diseased specimens, and inferior trees, such as beech, should not be practiced. The diseased and dying trees will be a menace to the remaining healthy ones, and the beech, ironwood, dogwood, and other inferior species which remain will scatter their seed over the ground, and very largely make up the future stand. In cutting, therefore, or in selling the standing timber, provision should be made that these inferior species be taken down to a smaller diameter than the more valuable ones and that *all* defective trees be removed. To make such a provision effective, the owner should mark in some manner all the trees which he desires cut or all those which he wishes to retain in his woods. To induce the lumberman to take inferior species and small and defective trees, it may be necessary to make some concessions in regard to price. The trees which remain will be the nucleus of the future crop, and valuable species should be in the majority in sufficient quantities to seed up the cut-over areas.

Unless small trees bring higher prices per unit of measure than large ones, or unless they are of species which it is desirable to elimi-

nate, they should not be cut by the woods owner, nor should he allow lumbermen to cut them. Trees 10 inches and less in diameter cut only very small amounts of low-grade lumber; so that their value is very small. Ordinarily, if they are to be sawed into lumber, the lumberman figures on paying little or nothing for them. He can not afford to do otherwise. Trees of such sizes, however, are usually growing rapidly or will do so when the other trees are removed and they receive more sunlight. As they increase in size, they will cut not only more but higher grade lumber; and they will, accordingly, increase in value in a greater ratio than in size. It is apparent that they should not be cut.

In felling trees, care should be taken not to throw them into the midst of a group of young trees, otherwise these may be seriously broken or bent. Further, by the exercise of a little care when dragging the logs out of the woods, much breakage, bending, and trampling of the young growth, or "brush," can be avoided. It must be kept in mind at all times that this "brush" is the first stage in growth of the mature timber. Every care should be taken to prevent its destruction, particularly in the better species, because it represents an established growth several years in age. A new stand of seedlings may not only be difficult to obtain, but will not have the advantage of this several years of growth. When standing timber is sold, the lumberman should be charged with protecting this young material as fully as possible.

When cutting for his own use, the owner should, so far as possible, observe rules similar to those outlined for lumbering operations. Dead and defective trees can be used for cordwood; the poorer species may sometimes serve nearly as well as the better ones for a special farm need; damage to young growth can be avoided; and the operations can be carried on at such a season of the year and in such a manner as will aid effective sprout reproduction.

METHODS OF REGENERATION.

A very striking condition in by far the greater proportion of farm woods is the absence of small trees. In those few woods which are fully stocked with even-aged trees of relatively even sizes, smaller trees need not be expected nor should their growth be encouraged. Where, however, as is much more commonly the case, the woods is made up partly of mature and partly of decadent trees which should be cut and whose crowns do not fully shade the ground, there should be young trees coming up in the openings. Under normal condition, these young trees would be present, but because of pasturing and fires they do not start. Grass appears instead; and, if pasturing and fires continue, conditions become such that, without

aid, there is little possibility of securing a natural growth of young trees.

NATURAL RESTOCKING BY SEED.

If the woods has not been too badly abused and there is not a heavy sod of grass present, the exclusion of stock and fires will normally result in its restocking itself in time by natural seeding. Good seed years, however, occur only at intervals. Even with a good seed year, the seedling may not be able to get a start because of the sod, the packed condition of the soil, or unfavorable weather. Natural reproduction may, therefore, be very slow, becoming satisfactory in amount only after from 10 to 20 years. It will often be advisable, therefore, when there is a good crop of seed on the trees, to put the ground in such shape as to insure a good crop of seedlings. Before the seed is scattered from the trees in the autumn, the ground can be disk harrowed or cultivated, or hogs can be turned in to root up the soil. The seed will then lodge in the soft earth, where, upon sprouting, the roots may easily take hold. To prevent undesirable species from obtaining a foothold, any trees of such species large enough to bear seed should be cut at the time that pasturing is discontinued.

To secure natural reproduction the old stand will normally have to be removed in two or three cuttings, each taking from one-third to one-half of the trees. The first cutting is designed to open up the crown cover somewhat, so that the leaves on the forest floor may decompose more rapidly, the mineral soil become exposed, and the germination of seed be more certain. The remaining trees become more windfirm, and as a result of their crowns receiving more sunlight they produce more seed. When the forest floor is in good condition the second cutting can be made during the winter following a heavy seed year. With the removal of these trees the conditions will be favorable for the germination of the seed and growth of the seedlings. Neither of the first two cutting should be so heavy that enough light will reach the ground to encourage a heavy growth of weeds or grass. The third cutting should be made after the seedlings are well established and no longer in need of the protection of the old trees.

REGENERATION BY SPROUTS.

It is not always possible to secure a new growth through sprouts from the stumps of felled trees. Most conifers do not sprout effectively, and the majority of hardwoods do not sprout vigorously beyond the age of 60 years. Basswood and chestnut are exceptions, for they can be depended on to sprout well from healthy stumps up to an age of 100 years. Individual vigorous trees of other species may also often do likewise. Sprout regeneration, then, is especially

applicable to hardwood stands which are to be cut when young, as, for instance, stands which are to be cut over every 20 to 30 years for posts or fuel. It should be remembered that sprouting is most vigorous from low stumps. It is also better from the stumps of trees cut during the winter or very early spring. Such sprouts, moreover, are less liable to severe winter injury at the end of their first season's growth than are those arising after timber is felled during the summer.

In felling the trees, care should be taken to injure the stumps no more than can be helped, because the best sprouts will ordinarily arise from good, clean stumps. Because of the clean cut which it makes, the axe is a better tool than the saw in felling trees where regeneration by sprouts is desired. Regardless of what tool is used, the surface of the stumps should be slanting, so that water will not collect and promote rot.

PLANTING OR ARTIFICIAL SOWING.

Some woods are so run down that very little seed is produced and natural reproduction can not be secured even if the area is disked or harrowed, or at least can not be secured rapidly enough to be satisfactory. Often it is desirable to grow different species than those present or to grow a greater proportion of one species than another. Sometimes no woods exist at all, but one is desired. In these cases artificial sowing or planting is necessary.

Where it is desired to establish a wood lot by sowing or planting, the areas to be selected for the purpose merits some attention. A large percentage of the farmers in the unwooded plains region have planted woods around their buildings and feed lots, primarily for protective purposes. Although the trees were usually planted on very good agricultural soils, these men considered that tree production was justified even though the wood produced was not equal in value to the agricultural crops which could be grown on the same land. The monetary value of the protection to live stock and the saving which it has meant in winter fuel is difficult to estimate. Determinations have been made, however, in regard to the effect of trees as windbreaks upon the wind velocity and upon crops protected by them from the prevailing summer winds. It has been found in the prairie region that through the protection afforded by the most efficient grove windbreaks, the yield in farm crops is increased to the extent of the crop that could be grown on a strip three times as wide as the height of the trees.[4]

Where protection is not considered essential, the logical places for establishing a woods are on those portions of the farm which

[4] Forest Service Bulletin 86, "Windbreaks," 1911.

FIG. 6.—Knolls on which timber may possibly be the most profitable crop.

are so steep or which have a soil so rocky, sandy, or wet that the returns from agricultural crops are very meager. (See figs. 5 and 6.) Steep hillsides in particular are liable to erosion; and even though good returns can be secured for a few years from growing agricultural crops on them, they are likely eventually to become so eroded as to be practically useless for such purposes. Such lands can in the long run be more profitably devoted to the growing of timber. Low lands which are not satisfactory for the growing of farm crops will produce excellent stands of some species of timber within their natural range, such as cottonwood, red gum, elm, swamp white oak, and others of a moisture-loving kind.

Species.—The species of trees to be given preference in planting or sowing operations should be those which are native to the region and which are of the most rapid growth. (See Table 2.) Though some of the most rapid-growing trees shown in Table 2 are not at present so valuable commercially as the most slow-growing ones, their values are increasing and their future increase will probably be proportionately greater than that of the others.

Spacings.—The proper spacing to give in planting trees depends largely on the habit of the species and the character of the site. In general, the more tolerant the trees are of shade and the more unfavorable the site, the closer should be the spacing. Very close spacing reduces the number and the size of the branches, which means that the trees will be of higher lumber value. It means, however, a greater death rate among them due to competition, and a higher initial cost of planting because of the greater number of trees required per given area.

On the unfavorable sites, close spacing is best. The same is true even on the better sites when cultivation can not be practiced for the first two or three years. The greater number of trees per acre offsets the higher mortality when first set out, and it results in better protection of the soil through the greater amount of shade furnished.

Species which are tolerant, that is, species that will grow well under shade, such as hard maple, beech, spruce, and hickory, can be spaced more thickly than those which are not tolerant, such as cottonwood, red pine, and black walnut. The best results will ordinarily be secured by sowing or planting a mixture of species, such as the cottonwood and soft maple, the black walnut and hickory or white oak, or the yellow popular and hard maple. In these cases the cottonwood, black walnut, and yellow poplar would be spaced 8 to 12 feet apart and the soft maple, hickory or white oak, and hard maple would be planted midway between them. Such a combination induces rapid height growth of the first-named kinds of trees and causes them to shed their lower branches early in life; but because of the ability of the maple, hickory, and oak to live under the shade of the cottonwood, walnut, and poplar, the ground is kept well shaded and in good condition. It being kept in mind that where wide spacings are followed, it is desirable to fill in between with more slowly growing but tolerant trees; spacings about as indicated in Table 3 should be given when the trees are to be grown to an age of 40 years or more. It is not intended to thin the stand at an earlier age.

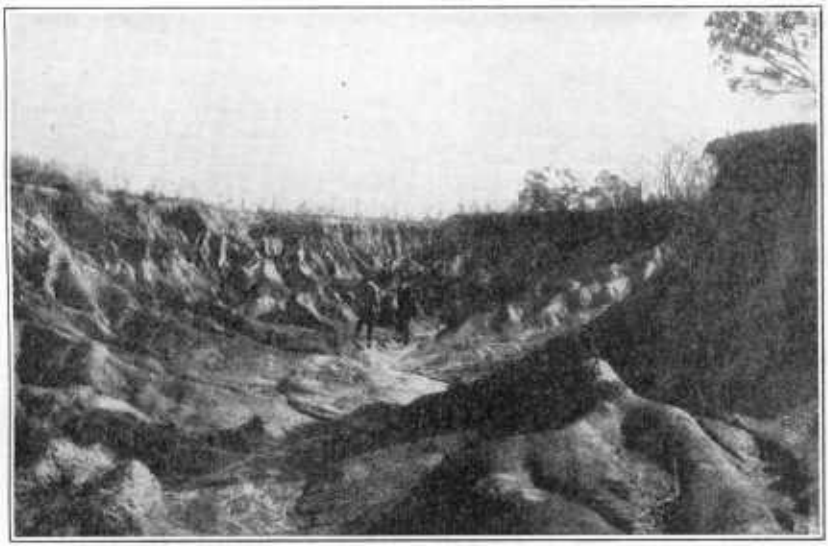

FIG. 7.—Erosion gulley which could have been prevented and may now be checked by forest planting.

TABLE 3.—*Spacing to be followed in forest plantation.*

Spacing in feet.					
12 by 12	8 by 8	7 by 7	6 by 6	5 by 5	4 by 5
Number of trees required per acre.					
303	680	889	1,210	1,743	2,178
Cottonwood.	Yellow poplar. Red gum. Loblolly pine. Slash pine.	Shortleaf pine. Chestnut. Black locust. Bald cypress.	White pine. Red pine. Red oak. Black oak. Black walnut. White ash.	Hickory. White oak. Chestnut oak. Bur oak. Post oak. Red elm. Basswood.	Hard maple. Yellow birch. Beech. White spruce. Red spruce. Fir.

The species in the last two columns will withstand considerable shade without being killed, and accordingly are the ones which can most safely be used in planting midway between such trees as are shown in the first three columns.

If seed are to be sown rather than trees planted, the quantity to be used per acre depends upon a number of considerations, such as the quality of the seed, the amount of preparation given the soil, the danger of destruction of the seed by squirrels, mice, birds, etc., its price, the rate of growth of the seedlings, and their sensitiveness to frost, drought, and other such damage. If the seed is scattered broadcast on soil prepared by plowing and harrowing like grain, some such amounts as follow will be required per acre:

White and chestnut oaks	bushels	12	Fir	pounds	45
Red and black oaks	do	8	Spruce	do	6
Ash	pounds	40	White pine	do	8
Beech	do	130	Red pine	do	5
Maple	do	40	Slash pine	do	[5] 3
Elm	do	24	Chestnut	bushels	8
Birch	do	32	Hickory	do	8

If the seed are to be placed in prepared spots evenly spaced over the area, two or three such seed as walnuts, hickory nuts, or acorns should be placed in each spot and about 10 of any of the other species. This is simply to guard against failure due to the seed's not sprouting, its destruction by rodents, or the death of some of the seedlings after sprouting has occurred. The total quantity required per acre is about one-fourth to one-third that necessary in broadcast sowing.

Stock.—In general there is more certainty of success from planting trees grown in a nursery than from sowing seed directly on the

[5] To be sown broadcast in grass and run over with spike-tooth harrow.

permanent site. The nut-bearing trees, however—walnut, oaks, and hickories—develop during their first year a deep taproot with very few laterals. This rather unfits them for growing in a nursery and later removing them to the field. The most practicable method with these species is to sow the nuts directly in cultivated spots in the field. Fall sowing is usually preferable to spring sowing unless there is danger of the nuts being disturbed by rodents.

One-year-old hardwood seedlings and two or three year old nursery-grown coniferous seedlings or transplants are the best classes of stock for planting. They are not so large as to be unduly expensive, and ordinarily small stock is more likely to succeed than large. Transplant stock of coniferous species usually has a better root and is sturdier than seedling stock. Accordingly it is more suited for planting on inhospitable sites and on all sites where no cultivation can be given following planting.

Hardwood seedlings can very easily be grown for planting. The seed can be collected locally or bought. It should be sown in prepared beds in much the same manner as a vegetable crop, and the young trees will require no more attention than such a crop. Coniferous seedlings or transplants require more attention for their successful production, and it will usually be best to purchase such stock from a reputable nurseryman or from the State nursery, if one is maintained. At present the following States maintain their own nurseries and distribute trees either free or practically at cost to planters within the State: Maine, New Hampshire, Vermont, Massachusetts, New York, Pennsylvania, Maryland, Virginia, Ohio, Michigan, North Dakota, Kansas, Wisconsin, and Kentucky.

If purchased from nurserymen, the cost of hardwood stock will range from $2 to $10 per thousand trees, and that of conifers from $3 to $12. A list of the nurseries which handle stock suitable for forest planting can be secured from the Forest Service, Washington, D. C., for all the more important species.

TABLE 4.—*Average growth of various species in different regions.*

Species.	Region.	Age. 20 years. Diameter at height of 4½ feet.	20 years. Height.	30 years. Diameter at height of 4½ feet.	30 years. Height.	40 years. Diameter at height of 4½ feet.	40 years. Height.	50 years. Diameter at height of 4½ feet.	50 years. Height.	60 years. Diameter at height of 4½ feet.	60 years. Height.	80 years. Diameter at height of 4½ feet.	80 years. Height.	100 years. Diameter at height of 4½ feet.	100 years. Height.
		Inches.	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
Aspen	Maine	2.4- 5.3	17-40	3.6- 8	28-55	4.7-10.4	39-66	5.8-12.7	50.75	7.0-14.8	57-81	9.3-19.2	64-87	11.7-23.3	66-89
Northern white cedar	Minnesota	.7	4.7- 8	1.2	5.7-11	1.6	13	2.1	15	2.8	18	4.2	25	6.2	32
Ash, white	New York (good soil)	4.5- 8.2	34-52	7.1-12.2	47-67	9.4-15.3	57-75	11.2-17.7	65.79	13.1-19.6	71-81	16.5-22.8	81-83	.....	.....
Do	Ind. (fair to poor upland)	1.6- 2.5	17-34	2.5- 4.1	26-45	3.5- 5.9	34-54	4.6-8.2	41-62	6.0-10.9	47-68	10.3-18.4	57-78	.....	.....
Ash, green	S. Carolina (bottom land)	4.9- 9.4	41-57	7.1-12.8	52-69	9.1-15.7	62-79	11.0-18.5	70-87	12.9-21.1	78-95	16.4-25.9	90-107	19.7-30.5	100-117
Do	Arkansas (bottom land)	4.9- 7.8	31-(?)	7.4-11.4	45-(?)	9.7-14.6	57-(?)	11.7-17.4	67-(?)	13.5-19.9	76-(?)	17.0-24.2	92-(?)	20.1-28.1	105-(?)
Basswood	Michigan and Wisconsin	2.2- 3.3	23-32	3.6- 5.1	34-44	5.0- 6.9	43-54	6.5- 8.8	52-63	7.9-10.7	59-70	10.9-14.3	71-80	13.8-17.6	78-85
Beech	Michigan	.7- 1.3	13-19	1.5- 2.3	21-28	2.3- 3.3	28-35	3.0- 4.4	33-42	3.8- 5.4	39-48	5.4- 7.5	48-59	7.1- 9.6	57-68
Do	New York	1.0- (?)	10-16	1.5- (?)	14-23	2 0- (?)	18-30	2.5- (?)	22-36	3.1- (?)	26-41	4.6- (?)	33-52	6.4- (?)	41-61
Birch, yellow	Michigan and Wisconsin	1.1- 2.1	20-30	1.7- 3.3	26-39	2.3- 4.6	31-48	3.0- 5.8	37-54	3.8- 7.1	43-60	5.6- 9.8	53-68	7.7-12.5	62-73
Do	New York	1.8- (?)	14-22	2.6- (?)	19-31	3.5- (?)	24-40	4.5- (?)	29-47	5.4- (?)	33-53	7.4- (?)	39-64	9.4- (?)	46-74
Cedar, red	Alabama (open stand)	3.9	19.6	6.9	27.1	9.3	.....	11.2	.....	12.8	.....	15.6	.....	.....	.....
Do	Alabama (forest grown)	1.3	13.0	2.7	23.2	4.4	33.4	6.5	.....	8.9	.....	13.9	.....	.....	.....
Do	New York (forest grown)	1.9	.....	2.8	.....	3.6	.....	4.2	.....	4.8	.....	.....	.....	.....	.....
Chestnut	Maryland (sprouts)	6.8	42	9.3	57	11.4	69	13.4	77	15.1	83	18.0	90	19.8	93
Do	Maryland (from seed)	3.4	17	6.0	33	8.7	52	11.2	64	13.4	73	17.2	84	20.1	91
Do	East Tenn. (from seed)	.....	36-55	.....	46-71	.....	52-84	.....	57-92	.....	61-98	.....	66-107	.....	.....
Do	East Tenn. (cove type)	3.1	.....	5.6	.....	8.2	.....	11.1	.....	13.7	.....	18.4	.....	21.7	.....
Do	East Tenn. (slope type)	2.5	.....	4.8	.....	7.2	.....	9.4	.....	11.4	.....	14.5	.....	16.9	.....
Do	Connecticut	3.4	.....	6.4	.....	9.5	.....	12.6	.....	15.6	.....	21.7	.....	27.8	.....
Do	West Va. (slope type)	2.4	.....	4.3	.....	6.4	.....	8.4	.....	10.4	.....	14.4	.....	18.2	.....
Do	New York	4.9	.....	7.2	.....	9.4	.....	11.4	.....	12.9	.....	.....	.....	.....	.....
Cottonwood	Mississippi Valley	12.3	97	17.4	115	22.0	127	26.5	136	.....	.....	.....	.....	.....	.....
Do	South Carolina	12.6	.....	17.4	.....	21.4	.....	25.1	.....	28.2	.....	33.5	.....	37.6	.....
Bald cypress	Louisiana	5.2- 8.1	31-45	8.1-12.2	43-61	10.8-15.9	54-75	13.3-19.2	65-86	15.8-22.2	74-97	21.3- (?)	92-(?)	.....	.....
Do	Maryland	3.5-10.0	22-44	6.2-14.2	33-58	8.7-17.6	46-71	11.1-20.5	60-82	13.3-23.2	72-91	17.3-28.6	88-106	21.3-33.3	101-119
Elm, white	Michigan and Wisconsin	.9- 2.8	21	1.7- 4.3	28	2.5- 5.7	34	3.3- 7.0	40	4.1- 8.2	45	5.7-10.4	53	7.3-12.6	61
Do	New York	3.6- 5.9	24-39	5.2- 8.4	31-50	6.6-10.6	37-57	7.9-12.5	41-62	9.2-14.2	45-66	.....	.....	.....	.....
Fir, balsam	do	1.0- 1.3	14-22	1.8- 2.6	19-34	2.8- 4.0	27-45	3.8- 5.4	32-54	4.9- 6.5	36-61	6.5- 8.2	43-69	7.6- 9.5	48-73
Do	Maine	1.2	14-22	2.7	25-42	4.1	36-55	5.5	45-63	6.7	52-69	8.9	64-78	10.7	71-83
Gum, red	South Carolina [1]	7.9	.....	11.2	.....	14.2	.....	16.8	.....	19.2	.....	23.4	.....	26.9	.....
Do	Missouri	3.8	.....	6.3	.....	9.2	.....	12.2	.....	15.1	.....	20.9	.....	25.8	.....
Hemlock	Michigan	.7- 2.0	8-18	1.3- 3.9	12-21	2.1- 5.7	16-42	2.9- 7.6	20-53	3.8- 9.4	25-62	5.7-12.8	35-76	7.8-16.1	44-85
Do	Southern Appalachians	.2- 4.0	(?)-29	.9- 6.7	9-41	1.3- 9.0	11-53	1.9-11.2	14-63	2.4-13.1	17-71	3.6-16.9	24-86	4.9-20.6	31-98
Do	New York	.4- 1.5	7-17	.9- 2.9	10-28	1.4- 4.4	13-39	1.9- 5.9	16-49	2.5- 7.4	20-58	4.0-10.5	28-73	5.5-13.8	36-84

Hickory	New York	3.6		5.4		7.1		8.6		10.0					
Mockernut	Ohio Valley	2.5		4.3		6.0		7.7		9.3		12.5		15.7	
Pignut	do	1.8		3.1		4.4		5.7		7.2		10.0		12.9	
Shagbark	do	1.7		2.9		4.1		5.3		6.5		9.0		11.6	
Pignut	Northern Kentucky and southern Indiana (fair to good soil second growth).	2.0	19	3.2	32	4.4	42	5.5	51	6.8	58	10.0	69		
Shagbark		2.8	18	4.0	32	5.4	43	6.8	51	8.0	58	10.5	70		
Bitternut		4.0	24	6.0	40	7.6	52	9.2	62	11.4	69				
Pignut	Northern Kentucky and southern Indiana (coppice; red clay soil).	3.8	31	5.5	43	7.0	52	8.5	59						
Shagbark		4.4	26	6.3	38	7.4	46	8.6	54						
Locust, black	Kentucky (close stand)	5.2		7.1		8.7									
Do	Kentucky (broken stand)	6.0		9.0		10.7									
Do	Kentucky (open stand)	9.3													
Maple, sugar or hard.	Michigan and Wisconsin	0.5–1.2	10–18	1.2–2.3	18–29	1.9–3.6	25–39	2.7–4.9	32–48	3.5–6.3	38–55	5.2–9.1	49–67	7.0–11.9	58–75
Do	New York	1.3	12–26	1.9	18–37	2.7	23–46	3.5	28–53	4.3	32–58	6.0	41–68	7.8	48–76
Oak, black	Tennessee (ridge)	4.0	29	6.8	40	9.5	51	11.3	61	12.4	70	14.2	83		
Do	Tenn. (cove and slope)	3.8		6.6		9.3		11.5		13.0		14.7			
Do	Kentucky (upland and bottom).	4.4		6.9		9.4		11.3		12.6		13.8		14.4	
Do	Southern Appalachians (sprouts):														
	Ridge	4.9	38.3	6.1	47.4										
	Slope	5.4	48.0	7.1	59.0										
Oak, black and scarlet.	Missouri (seedling)	2.6		4.4		6.2									
Do	New York (seedling)	2.2		3.8		5.3		6.7		7.7					
Do	New York (sprouts)	3.4		4.9		6.2		7.2		8.2					
Oak, chestnut	Tennessee (ridge)	0.7–0.9	29	1.6–1.9	40	2.5–2.9	47	3.4–4.0	53	4.3–5.1	58	6.1–7.4	63	7.9–9.8	
Do	Tennessee (cove)	1.7		3.7		5.6		7.3		8.9		11.6		13.9	
Do	Tennessee (slope)	1.2		2.4		3.4		4.3		5.4		7.7		10.0	
Do	Kentucky (ridge)	.7		1.6		2.5		3.4		4.3		6.1		7.9	
Do	New York (sprouts)	3.9		5.3		6.6		7.6		8.4					
Oak, red	North Carolina (slope)	1.5		2.8		4.4		5.9		7.5		11.3		15.3	
Do	Tenn. (cove and slope)	3.6	32	6.9	46	10.3	60	12.7	72	14.1	80	15.5			
Do	Kentucky (upland and bottom).	5.0		7.6		10.3		12.4		14.1					
Do	New York (sprouts)	4.1		6.1		8.0									
Oak, swamp white.	New York (seedling)	2.7		4.4		5.9		7.1		8.3		10.2			
Do	New York (sprouts)	4.5		6.2		7.6		9.0		10.3					
Oak, white	Missouri	1.1		2.2		3.2		4.2		5.2		7.2		9.1	
Do	West Va. (second growth)	3.1		4.4		5.4		6.3		7.2		8.6		10.0	
Do	New York (seedling)	2.2		4.1		5.7		7.1		8.2					
Do	New York (sprouts)	3.9		5.4		6.6		7.6		8.4					
Do	Kentucky (upland and bottom).	3.6		5.6		7.5		8.7		9.8		11.2		12.2	
Do	Kentucky (slope)	1.1		2.2		3.2		4.2		5.3		7.4		9.7	

[1] Diameter on stump.

TABLE 4.—*Average growth of various species in different regions*—Continued.

Species.	Region.	Age.													
		20 years.		30 years.		40 years.		50 years.		60 years.		80 years.		100 years.	
		Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.
		Inches.	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
Oak, white	Tennessee (slope)	0.7	.....	1.7	.....	2.6	.....	3.4	.....	4.3	.....	6.3	.....	8.1	.....
Do	Tennessee (cove)	.9	.....	2.0	.....	3.0	.....	4.1	.....	5.1	.....	7.1	.....	9.1	.....
Do	Tenn. (second growth):														
	Cove and slope	3.3	25	5.9	38	8.3	51	10.3	63	11.7	71	13.3	77	.....	.....
	Ridge	3.4	22	5.7	32	8.0	43	10.0	53	11.5	63	13.4	75	.....	.....
Do	Southern Appalachians (sprouts):														
	Ridge	3.9	33.2	4.4	40.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Slope	4.2	31.8	5.1	37.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pine, jack	Minnesota (poor, sandy soil).	3.3–3.9	.....	4.8–5.9	.....	6.0–7.4	.....	7.0–8.7	.....	7.8–9.9	.....	9.3–11.8	.....	.....	.....
Do	Minnesota (good, sandy loam).	4.4–5.5	.....	6.2–7.9	.....	7.5–9.4	.....	8.5–10.8	.....	.....	.....	.....	.....	.....	.....
Pine, loblolly	South Carolina (old field)	6.1	38	10.0	59	13.3	75	15.9	86	18.1	94	21.5	104	24.5	111
Do	South Carolina (thicket)	4.0	.....	7.4	.....	10.5	.....	13.0	.....	14.9	.....	17.7	.....	20.0	.....
Do	Arkansas (thicket)	3.1	.....	5.0	.....	6.9	.....	8.8	.....	10.7	.....	14.1	.....	17.2	.....
Do	Eastern Texas: [2]														
	Pure stand on wet prairie.	6.7	.....	8.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Pure stand on light, fairly well-drained soil.	7.6	.....	12.8	.....	16.9	.....	20.0	.....	22.3	.....	.....	.....	.....	.....
	Mixed with hardwoods, poorly drained soil.	2.2	.....	3.8	.....	5.6	.....	7.8	.....	9.8	.....	13.9	.....	17.4	.....
	Mixed with hardwoods, well-drained, fertile soil.	6.1	.....	9.5	.....	12.4	.....	15.0	.....	17.2	.....	.....	.....	.....	.....
Do	Maryland	5.0–6.8	33–55	6.4–9.1	46–69	7.7–11.0	54–78	8.8–12.7	60–87	.....	.....	.....	.....	.....	.....
Pine, longleaf	Alabama	1.4	10	2.8	22	4.5	33	6.2	38	7.9	49	11.2	64	14.0	76
Do	South Carolina	1.2–2.2	.....	3.0–3.9	.....	4.9–5.5	.....	6.7–7.1	.....	8.5–8.6	.....	11.3–12.4	.....	13.9–15.5	.....
Do	Texas	1.7	24	3.3	33	5.0	50	6.6	64	8.2	71	10.8	88	13.1	93
Do	Texas (second growth)	1.5–2.8	.....	3.1–5.8	.....	4.9–8.4	.....	6.8–10.4	.....	8.6–11.6	.....	11.5–13.7	.....	13.9–15.2	.....
Pine, red or Norway	Wisconsin	2.8–5.4	35.56	5.7–10.3	58–78	8.0–13.8	70–86	9.9–16.6	77–91	11.7–18.8	82–94	14.6–21.9	88–98	16.9–24.2	91–101
Do	Wisconsin (ridge)	2.7	.....	5.2	.....	7.5	.....	9.3	.....	11.0	.....	13.7	.....	15.9	.....
Do	Wisconsin (ravine)	3.3	.....	5.8	.....	8.2	.....	10.3	.....	12.1	.....	15.3	.....	17.6	.....

Do	Minnesota	2.8–6.8	21–49	4.9–10.1	35–68	6.6–12.6	47–78	8.2–14.6	58–84	9.6–16.4	66–88	12.0–19.2	76–92	13.9–21.3	82–94
Do	Minnesota (mixture with jack pine)	1.7–2.4	.....	3.4–4.2	.....	4.8–5.7	.....	6.0	.....	6.9	.....	.....	.....	.....	.....
Pine, scrub	Maryland	4.8–6.8	33	6.5–8.6	46	7.8–10.1	55	9.0–11.4	63	10.1–12.8	.....	.....	.....	.....	.....
Pine, shortleaf	Arkansas	5.7–7.2	45–51	8.1–9.9	54–59	10.1–12.0	60–64	11.7–13.6	64–68	12.9–15.1	66–71	15.0–17.5	71–76	16.6–19.4	74–81
Do	Missouri	1.6	.....	3.4	.....	5.1	.....	6.7	.....	8.2	.....	10.7	.....	12.7	.....
Do	N. C. (second growth)	6.3–11.6	50–69	8.4–14.5	61–73	9.9–16.5	65–75	11.0–17.6	68–76	11.7–18.4	69–77	13.0–19.4	71–78	.....	.....
Pine, white	New York	7.0–7.4	26–27	10.2–11.2	40–42	11.8–13.6	52–55	12.8–15.5	60–65	.....	.....	.....	.....	.....	.....
Do	New Hampshire	2.3–4.0	14.5–24.5	3.9–6.4	28.5–44	5.5–8.6	43–61	7.0–10.8	54–75	8.6–12.8	64–86	11.7–16.5	78–102	14.5–19.8	87–113
Do	Minnesota	2.8	.....	5.3	.....	7.6	.....	9.2	.....	10.7	.....	13.0	.....	14.8	.....
Do	North Carolina (slope)	2.4	.....	4.7	.....	6.9	.....	9.1	.....	11.2	.....	15.0	.....	18.0	.....
Do	Tennessee (slope)	2.2	.....	4.4	.....	6.4	.....	8.5	.....	10.7	.....	14.5	.....	17.7	.....
Do	Tennessee (cove)	1.9	.....	5.6	.....	8.5	.....	11.3	.....	13.9	.....	18.6	.....	22.1	.....
Poplar, yellow	Tennessee	4.6–5.7	40	7.7–8.5	61	10.5–11.1	78	12.8–13.7	87	14.7–16.1	94	.....	.....	.....	.....
Do	Tennessee (cove)	3.0–3.4	.....	5.0–5.4	.....	6.9–7.3	.....	8.7–8.9	.....	10.4	.....	13.4–13.8	.....	16.3–17.0	.....
Do	North Carolina (cove)	4.6	.....	7.7	.....	10.5	.....	12.8	.....	14.7	.....	17.3	.....	19.5	.....
Do	Virginia (Quality I—seedlings)	6.5	50	9.7	64	12.6	74	15.2	83	17.3	.....	.....	.....	.....	.....
Do	Virginia (Quality II—seedlings)	4.6	36	7.4	50	10.2	64	13.0	78	15.8	.....	20.6	.....	24.6	.....
Do	Virginia (sprouts)	7.4	.....	10.2	.....	12.7	.....	15.0	.....	.....	.....	.....	.....	.....	.....
Spruce, red	Maine	.1	.....	.6	.....	.8	.....	1.1	.....	1.5	.....	2.2	.....	3 2	.....
Do	New York (spruce type)	.....	5	.4	6	.7	8	1.0	9	1.3	11	2.0	14	2.9	18
Do	New York (spruce hardwood type)	.3	5	.7	7	1.1	8	1.5	10	2.0	12	3.2	18	4.4	27
Do	New York (balsam swamp type)	.....	2	.....	4	.4	5	1.1	7	1.8	9	3.1	16	4.2	26
Do	N. H. (second growth)	2.0	13–21	4.2	24–32	5.9	35–43	6.9	43–51	7.6	49–58	8.9	56–66	.....	.....
Do	West Virginia	0.3–1.2	6–11	0.9–2.7	10–20	1.5–4.3	13–30	2.1–5.8	17–39	2.7–7.2	2)–47	4.1–9.8	29–60	5.3–12.3	36–72
Tamarack	Minnesota (upland)	1.5–1.7	.....	2.5–3.4	.....	3.3–4.9	.....	4.2–6.1	.....	4.7–7.0	.....	5.9–8.5	.....	6.9–10.0	.....
Do	Minnesota (swamp)	1.6	.....	2.9	.....	4.0	.....	5.0	.....	5.8	.....	6.9	.....	7.8	.....
Pine, slash	Georgia (low upland)	7.5–9.4	42–60	9.8–12.3	60–73	11.5–13.8	68–80	12.0–15.2	75–86	.....	.....	.....	.....	.....	.....
Do	Florida (flat, wet)	5.4–7.3	34–50	6.8–9.9	48–65	8.0–11.9	55–72	9.0–12.5	65–76	.....	.....	.....	.....	.....	.....

[2] Diameters inside bark on stumps 2 feet to 3.5 feet high.